VERIFICATION STATEMENT

In accordance with ISO 14034:2016
Environmental Technology Verification

Technology & Company Information		
Technology Name	**Company**	**Technology Type & Application**
ASCO CO_2 Stack Gas Recovery Plant	InnoTech Alberta Inc. https://innotechalberta.ca ASCO Carbon Dioxide, Inc. https://www.ascoco2.com/us HTC Extraction Systems https://htcextraction.com	Amine-based CO_2 capture from flue gas

Verification Parameter	Verified Performance
Operational Scale	69,941 SCF/day Flue Gas Input (avg) 5.83 tonne/day CO_2 input (avg) 86,410 SCF/day Flue Gas Input (max) 7.54 tonne/day CO_2 input (max)
CO_2 Capture Efficiency	82.7% (average)
CO_2 Production	4.79 tonnes CO_2 captured /day (avg) 6.13 tonnes CO2 captured /day (max)
Energy Usage	648 kWh/day Electricity 0.134 kwh/kg CO_2 Captured 37.3 mcf/day Natural Gas 0.0076 mcf/kg $CO_2$2 Captured
Water Usage	Not Observed

Verifier Information			
Verification Body	**Lead Verifier**	**Verification Body Accreditation**	**Verification ID**
350Solutions, Inc. https://350Solutions.com	Tim Hansen	ANAB Cert. AI-2618 for ISO:IEC 17020-2012 / ISO 14034-2016	VS-XPB6

350 VERIFIED
ISO 14034

InnoTech ALBERTA
A SUBSIDIARY OF ALBERTA INNOVATES

ASCO
All about CO_2

HTC PURIFICATION

Issue Date: April 15, 2021

ANAB ACCREDITED
ISO/IEC 17021
INSPECTION BODY

ENVIRONMENTAL TECHNOLOGY VERIFICATION STATEMENT

InnoTech ALBERTA
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ASCO
All about CO_2

HTC PURIFICATION

Technology Name:	ASCO CO_2 Stack Gas Recovery Plant
Technology Type:	Amine-based CO_2 capture
Application:	CO_2 capture from power plant or industrial flue gas
Company:	InnoTech Alberta Inc. (https://innotechalberta.ca) ASCO Carbon Dioxide, Inc. (https://www.ascoco2.com/us) HTC Extraction Systems (https://htcextraction.com)
Verification Body:	350Solutions, Inc. - ISO/IEC 17020:2012 and ISO 14034 Environmental Technology Verification, Certificate Number AI-2619
Lead Verifier:	Tim A. Hansen, P.E. - 350Solutions, Inc.

TECHNOLOGY DESCRIPTION

InnoTech Alberta Inc. owns and operates a carbon dioxide (CO_2) capture system developed and provided by ASCO. The SGR285 CO_2 stack gas recovery system is installed and operated at the Alberta Carbon Conversion Technology Center. The technology utilizes an amine solution solvent and optimized packing technology to provide a highly efficient CO_2 extraction process that is also resistant to O_2 presence in the source stream.

A basic summary of the process is provided in Figure 1.

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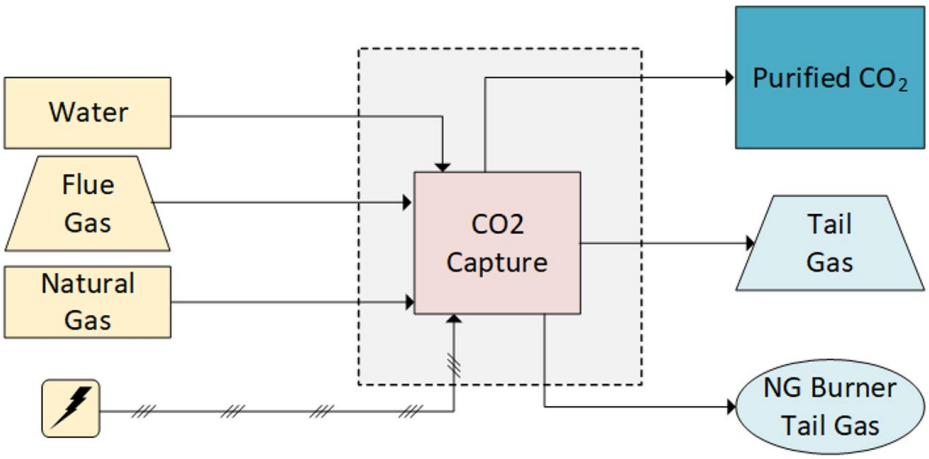

FIGURE 1. InnoTech-ASCO/HTC CO_2 Capture System Process Summary

A slip stream of flue gas from the natural gas-fired boilers at the Enmax Shepard Energy Centre, a 860-MW combined cycle power plant, is sent to the capture system. This flue gas is first cooled prior to entering the CO_2 extraction process. Flue gas then enters the CO_2 gas absorber, through which the amine-based solvent is fed. Once absorbed, the CO_2 gas is carried within the enriched solvent stream for CO_2 recovery, while remaining products of combustion in the flue gas are vented off the top of the absorber tower. The solvent, enriched with CO_2, passes to the stripper tower which uses reboiled lean solvent combined with tower and structured packing material to liberate the CO_2 gas from the enriched solvent stream. The exit CO_2 gas from the stripper is produced at a controlled temperature and pressure, and provided as a final product stream consisting of saturated CO_2.

FIGURE 2. InnoTech-ASCO/HTC CO_2 Capture System Hot Oil Supply, Adsorber, and Stripper Columns (L) and Stripper Column (R)

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VERIFICATION DESCRIPTION

The primary objective of this assessment was to verify the performance of the InnoTech - ASCO system while operating during a demonstration period for the NRG COSIA Carbon XPRIZE competition. Verification parameters were assessed quantitively using data generated from continuous monitoring of flue gas inlet and product outlet, monitoring of natural gas and electricity usage by the system, and monitoring of process operating conditions. The performance claims specified for verification include:

Performance Claim 1 – Operational Size: Operational size is defined as the average daily rate of flue gas CO_2 fed into the conversion system during operations and represents the operational scale achieved during the XPRIZE competition demonstration. Performance results are verified within the range of relevant operating conditions summarized in Table 2 that were evident during this demonstration.

Performance Claim 2 – CO_2 Capture Efficiency: Defined as the mass ratio of the CO_2 in the product gas stream and CO_2 in the input flue gas, expressed as a percentage. The performance claim is presented as the daily average capture efficiency during the demonstration period, within the operational conditions defined during the period. CO_2 concentration and flow rates were determined by process gas analysis and gas flow meters.

Performance Claim 3 – CO_2 Product Gas Production Rate: The average daily rate of CO_2 gas product produced during the demonstration period and within the range of operating conditions. CO_2 concentration and flow rates were determined by process gas analysis and gas flow meters.

Performance Claim 4 – Energy Usage per kg CO_2 Product: For every kg of CO_2 in product gas, the conversion system required electric power and natural gas to complete the capture process. Energy use is normalized to CO_2 output.

Performance Claim 5 - Water Usage per kg CO_2 Product: The conversion system developer claims no water is used in the process after initial charge of amine solvent and water, except for occasional makeup or amine-water replacement.

After initial reviews of the technology and following the Verification Plan, performance verification was specified using independent performance data generated during the verification at the Alberta Carbon Conversion Technology Center (ACCTC) in the Fall of 2020 during the NRG COSIA Carbon XPRIZE competition. Using data that was determined to be relevant, valid, and of sufficient quality to support verification, 350Solutions assessed the performance of the technology. The verification also statistically examined variability and confidence intervals in the supporting data used to verify performance claims including comparative sample analytical results and analytical variability.

VERIFICATION OF PERFORMANCE

Verified results for each performance claim and associated parameter are summarized in Table 1. For all results, a total of 85 days of data collected between September 12, 2020 and December 5, 2020 was used. The summary in Table 1 presents the in-field verified values and associated uncertainties for each Verification Parameter. Uncertainties are presented as the combined Type A (statistical) and Type B (measurement) uncertainties of the parameters.

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TABLE 1 InnoTech-ASCO/HTC CO_2 Capture System Verified Performance

Verification Parameter	Verification Value
Operational Scale	
Flue Gas Input (SCF/d)	69,941 ± 3,660 (avg)
CO_2 Input (tonne/d)	5.83 ± 0.3 (avg)
Flue Gas Input (SCF/d)	86,410 ± 968 (max)
CO_2 Input (tonne/d)	7.54 ± 0.08 (max)
CO_2 Capture Efficiency (%)	82.7% ± 4.1%
CO_2 Production Rate	
(tonne CO_2/d)	4.79 ± 0.05 (avg)
(tonne CO_2/d)	6.13 ± 0.07 (max)
CO_2 Product Composition[+]	98.2% CO_2 (saturated CO_2) (avg) *See note °C (avg) 0.47 bar_g (avg); 0 – 1 bar_g (range)
Energy Usage	
Electricity (kWh/day)	648 ± 108
Electricity (kWh / kg CO_2 captured)	0.134 ± 0.025
Natural Gas (mCF / day)	37.3 ± 5.3
Natural Gas (mCF / kg CO_2 captured)	0.0076 ± 0.0005
Water Usage	
(kg/day)	0
(kg/kg ethylene/product)	(no additional water usage was observed for process operations during the verification period)**

[+]CO_2 composition data is based on operational data from December 1-31, 2021, as data was not archived prior to this period. Because of CO_2 product line heat tracing, temperature remains stable, which results in stable product composition, as it is saturated CO_2 as verified by on-line analyzers.

**Captured CO_2 gas temperature was maintained in header via heat trace above approximately 10°C.*

***Additional water and amine usage was not observed during the 85-day operating period. However, additional amine and water usage may be required during longer term operation, as amine degradation and water loss may result in requirement for makeup.*

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Table 2 presents the operating conditions under which the Verification Parameters were observed during the demonstration period. These operating conditions have direct correlation to system performance and should be considered in conjunction with the verified performance.

TABLE 2. InnoTech-ASCO/HTC CO_2 Capture System Operating Conditions

Operating Parameters	Observed Average Value	Observed Range
Flue Gas Temperature at Capture Inlet	64.6°C	0 - 90.5°C
Flue Gas Pressure at Capture Inlet	18.4 kPa	2 – 62 kPa
Flue Gas Composition@		
CO_2	4.42%	3.52 – 5.17 %
O_2	13.6%	12.9 – 14.8%
N_2	80.15%	76.9 – 81.7%

@Flue gas composition from independent analytical samples.

The basis for the verification was an operational period of 85 days during which data was collected on process operations using on-site datalogging and PLC systems. Total system operations and operating characteristics for which data was reviewed and verified are summarized in Table 3.

TABLE 3. Operational Period

Verification Period Characteristic	Observed Value	Observed Range
Total Hours Operated	1827	19.4-24 hr/day
System Availability	96.7%+	NA

+System Availability is calculated for 30-day period 10/31/2020-11/29/2020, when system was fully operational and not idled due to decreased demand.

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DATA QUALITY

350Solutions, an ANAB accredited ISO/IEC 17020:2012 inspection body for ISO 14034 ETV, was contracted by XPRIZE to provide independent verification of the InnoTech-ASCO/HTC CO_2 Capture System (ASCO model SRG285). The verification process applied was based on 350Solutions' Standard Operating Procedure QSP-350-223-01: "ISO 14034 Environmental Technology Verification", the ISO Technical Committee 207 draft guidance document "*Environmental Technology Verification — E.T.V — Guidance to Implement ISO 14034*", and a technology specific Verification Plan. The objectives and approaches used for this verification were designed to apply these principles and processes to InnoTech-ASCO's application for verification and performance claims. Following ISO 14034 guidance, the data quality assessment included:

- Data quality assessment for the specified performance claims – including data validity audit, uncertainty analysis, instrument calibration;
- Assessment of ancillary data quality (operational conditions and associated measurements, relevance of observed process operations, representativeness of typical operations);
- Performer competence (testing, operations, instrumentation, and analytical providers);
- Measurement, sampling and analytical procedures (repeatability, accuracy, measurement equipment calibration and quality checks); and
- Data management and processing.

Assessment of the quality of data used to verify technology performance was based on three primary components:

- Conformance with the requirements of ISO Standards 14034 and 17025.
- Assessment of the scientific approaches and statistical analyses – specifically, evaluation of measurement uncertainty in laboratory and field demonstration test results, and the statistical analyses of measurement uncertainty.
- The quality of reference laboratory procedures and results and field instrumentation operation and calibration.

In broad terms, the data provided by InnoTech to verify performance were found to be acceptable for verification. Sound scientific approaches and statistical analyses are detailed in the Verification Report and demonstrate that the quality of data and data analyses support verification of the performance claims. Data quality was verified as acceptable based on the following data quality assessments:

- Review and verification of acceptable instrumentation, operational, and measurement SOPs and methods. InnoTech utilized quality industrial process instrumentation, provided factory calibrations that were generally NIST or otherwise traceable, and performed regular equipment calibrations when required. InnoTech also utilized standard operating procedures and logged all process activity, including irregular operations such as shut-downs or faults.
- Satisfactory verifier observation of facilities, equipment, instrumentation, and operations. On site observation was performed in November, 2020 during normal process operation.
- Review and observation of performer competence (qualifications and training policies),
- Satisfactory measurement and data analysis procedures (repeatability, accuracy, measurement equipment calibration and quality checks). Measurements were generally obtained via on-line process instrumentation and site data acquisition system. 350Solutions performed independent calculations based on process data from the system.

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All of the findings of the data quality review support verification of the performance claims and conform to the requirements of the standards.

Detailed results of the verification are presented in the Final Report titled *Environmental Technology Verification Report – InnoTech-ASCO/HTC CO_2 Capture*. (350Solutions 2021). The report can be made available to the interested parties upon request to InnoTech or ASCO.

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